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Piezoelectric properties of α-glycine and DL-alanine single crystals

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Glycine and alanine are amino acids that are used in the biosynthesis of proteins. The L-isomer of alanine is one of the 20 amino acids encoded by the human genetic code. D-alanine occurs in bacterial cell walls and in some peptide antibiotics. Recently, strong pyroelectric properties of mixed DL-alanine single crystals have been found [1]. α-glycine is crystallized in form of centrosymmetric nonpolar crystals and, therefore does not exhibit piezoelectric properties. However, recently was demonstrated that doping nonpolar crystals of amino acid with another amino acid leads to developing pyroelectric properties [2].

We present the results of studying piezoelectric properties in pure DL-alanine and α-glycine crystals doped with amino acids: L-alanine, L-serine, and phase transformations in pure DL-alanine crystals. Crystals were provided by Weizmann Institute of Science. Piezoelectric properties have been measured with high spatial resolution by piezoresponse force microscopy (PFM) using Asylum MFP 3D (Asylum Research, USA). Phase transformation was visualized by PFM.

α-glycine crystals doped with L-alanine demonstrated strong piezoelectric properties with the value of d_{eff} up to 50 pm/V. Crystals doped with L-serine demonstrated weaker piezoelectric properties with d_{eff} value up to 35 pm/V. Pure DL-alanine crystals demonstrated very weak piezoelectric properties and measured value of d_{eff} up to 10 pm/V. Furthermore, piezoresponse was measured at different angles between cantilever and crystallographic c-axis (vector PFM mode).

The temperature dependence of piezoelectric response was measured in the temperature range from 25 to 110°C. For doped α-glycine crystals piezoresponse reversibly decreases with temperature. While for pure DL-alanine crystals piezoresponse decrease is irreversible. However, after two weeks measurements were repeated experiment and found piezoresponse was back to its initial level.

Moreover, the kinetics of the phase transformation from piezoelectric to non-piezoelectric phase was investigated in DL-alanine crystals by in situ PFM visualization. The phase transformation was induced by high humidity (above 50%). The measured constant velocity of the phase boundary motion is about 4 nm/s.

1. E. Mishuk, I. Weissbuch, M. Lahav, I. Lubomirsky, *Crystal Growth & Design*, **14**, 3839 (2014).
2. S. Piperno, E. Mirzadeh, E. Mishuk, D. Ehre, S. Cohen, M. Eisenstein, M. Lahav, I. Lubomirsky. *Angewandte Chemie International Edition* **50**, 6513 (2013).